

THE FOT TOOL KIT CONCEPT

N94-23889

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ABSTRACT

Flight operations and the preparation for it has become increasingly complex as mission complexities increase. Further, the mission model dictates that a significant increase in flight operations activities is upon us. Finally, there is a need for process improvement and economy in the operations arena. It is therefore time that we recognize flight operations as a complex process requiring a defined, structured, and life cycle approach vitally linked to space segment, ground segment, and science operations processes. With this recognition we have developed an FOT Tool Kit consisting of six major components designed to provide tools to guide flight operations activities throughout the mission life cycle. This paper addresses the major components of the FOT Tool Kit and the concepts behind the flight operations life cycle process as developed at NASA's GSFC for GSFC-based missions.

The Tool Kit is therefore intended to increase productivity, quality, cost, and schedule performance of the flight operations tasks through 1) the use of documented, structured methodologies; 2) knowledge of past lessons learned and upcoming new technology; and 3) through reuse and sharing of key products and special application programs made possible through the development of standardized key products and special program directories.

1. BACKGROUND

GSFC is responsible for low earth orbiting scientific satellites. The evolution of GSFC missions over the years has resulted in dramatic changes in operations. Increased mission complexity, increased coupling between space, ground, science, and operations, new technology in space and ground systems, larger spacecrafts and payload sets, multi-mission sets with coordinated science campaigns, heavily utilized and loaded shared resource support systems, and other changes over the last ten

years has changed the demands on the flight operations teams both in the premission phase and during orbital operations. For example:

1. Spacecraft ten years ago had several hundred to a thousand telemetry parameters, and only several hundred largely pulse type commands. Today the missions have 2000 to 3000 telemetry parameters, over 1000 commands, commands with many attributes, options, and subfields, and more complex processes for interaction between subsystems.
2. With the advent of realtime science (as we move from survey missions to more dynamic realtime studies) the nature of mission planning is changing, moving away from advanced planning to near realtime and realtime resource and constraint management.
3. The increased utilization of flight software has added onboard processes that compliment the ground process, often simplifying operations under normal conditions but complicating the fault detection, identification, and resolution process.
4. The trend back towards smaller missions which are largely ground station-only supported require handling these increased mission complexities in short duration realtime events (typically 8 to 12 minutes).

It is clear that the nature of flight operations has changed.

Finally, the GSFC mission development model is growing. We have more new missions than we have experienced, flight operations development personnel to handle them. We can no longer count on an experienced workforce, and must develop tools to guide new operations engineers.

Due to these challenges on operations, we must now recognize the complex and full life cycle operations process. Accordingly, GSFC has

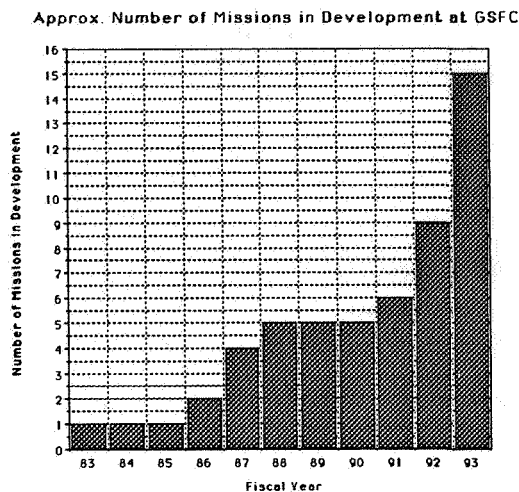


Figure 1: Mission Development Model

developed and implemented an operations engineering process. The intent is to build upon the principles of concurrent engineering, involving the user in the development from day 1, and building operations into the design. A cornerstone of this process is the FOT Tool Kit.

2. FOT TOOL KIT COMPONENTS

The FOT Tool Kit is the first comprehensive effort at collecting information to guide the operations development and implementation process. It has a full life cycle scope, is both forward and backward looking, and promotes reuse and sharing among Flight Operations Teams. It will assure a higher quality operations service built on proven principles of previous missions, and as a documented process allows for continuous process improvements. It consists of two main elements: 1) Methodologies, and 2) Support Tools.

2.1 Methodologies

Four methodologies are provided in the tool kit: 1) The Operations Engineering Methodology (OEM) document; 2) The Continuing Operations Methodology (COM) document; 3) The Flight Operations Management Methodologies (FOMM) document, and 4) The Training Methodologies (TM) document.

The Operations Engineering Methodologies document provides a work breakdown structure (WBS) for the operations effort required in the mission preparation phase. The WBS follows the operations engineering process. For each major WBS element, the document provides a template of information including a checklist of considerations, definition of key products and reviews, a process chart, and key inputs and interdependencies. All of the information is based on successful practices of past missions. It includes operations engineering processes for both within and across mission engineering, thereby supporting the mission engineering concept.

The Continuing Operations Methodology is a similar product based on a WBS for operations activities in the orbital operations phase. It provides recommendations for handling each task based on successful practices of previous missions.

The Flight Operations Management Methodology document, also based on a WBS, provides mission assessment models for defining the flight operations efforts, guidelines for schedule development, guidelines for management of the operations effort in both the premission and orbital operations phase, and methods for interacting with the space, ground, and science components of a mission (the mission engineer-

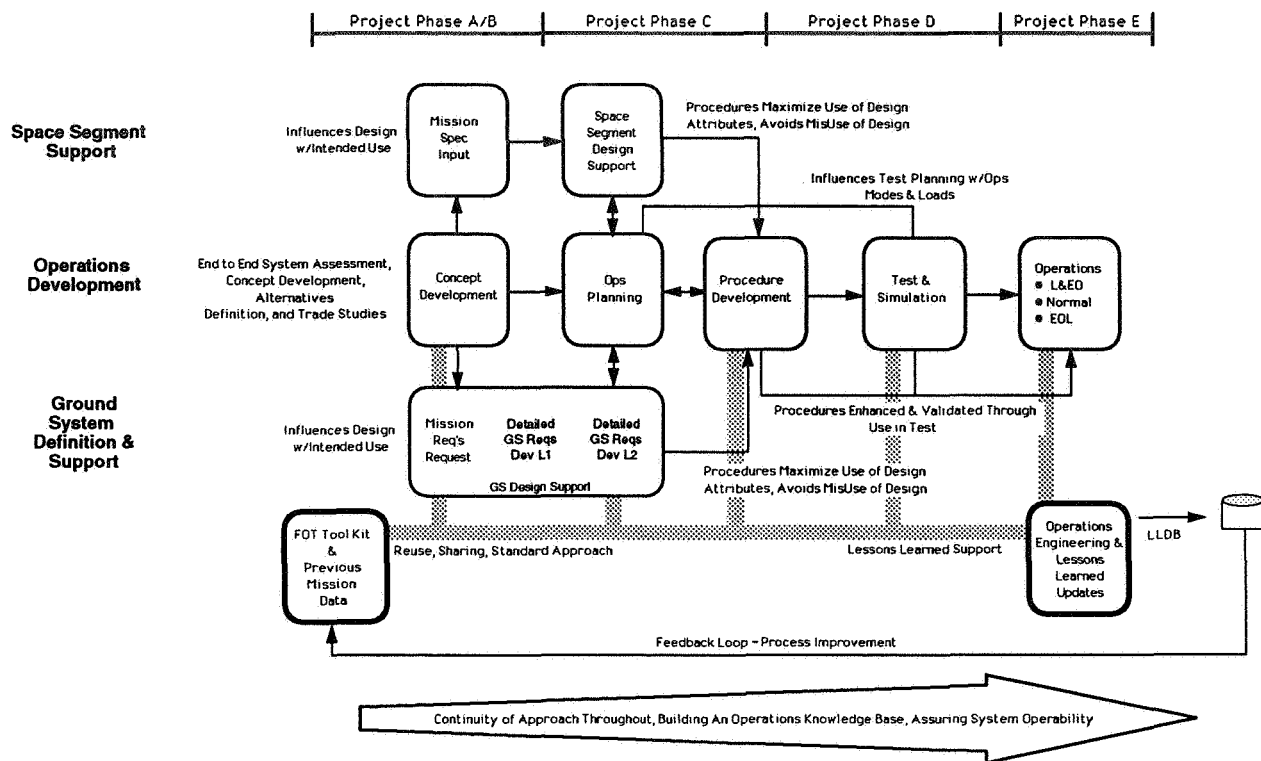


Figure 2: Operations Engineering Process

ing process).

Finally, the training methodology document addresses premission training, regressive training during orbital operations, and cross-training. It establishes minimum training requirements for the various positions on the FOT, and defines training methodologies. It also promotes continuing education.

2.2 Support Tools

Although missions vary, there is a foundation common to all. At GSFC we have found that approximately 50 to 60 % of a mission is common from mission to mission. Capitalizing on this reuse through commonality in approach for like functions has significant cost savings. The FOT Tool Kit support tools attempt to capitalize on reuse and sharing for economy and guidance to the new operations engineers. The FOT Tool kit consist of 4 main support tools providing assistance to the FOT during all phases of the development life cycle. It assures avoidance of reinventing the wheel through reuse and sharing, and will result in consistency across missions.

The support tools are: 1) the Operations Library; 2) the Lessons Learned Data Base System

(LLDBS); 3) the New Technology Data Base System (NTDBS); and 4) the Special Application Program Directory. The LLDBS and NTDBS provide a foundation of information which is both forward and backwards looking. They provide process improvement through past lesson learned, as well as new technology information supportive of advanced mission planning (new missions are designed to the technology that will be available at mission implementation versus designed to today's technology). Finally, the Special Application Program Directory offers insight into a variety of special tools developed by a host of FOT's, many of which can be easily modified and reused on new missions.

3. THE TOOL KIT AND CONTINUOUS IMPROVEMENT

Total Quality Management principles promote continuous improvement by refining processes. There must be a defined process from which to improve. This has not been the case at GSFC. Flight operations has been implemented by separate teams for each mission, has no formal process or policy definition, and has little feedback loop for

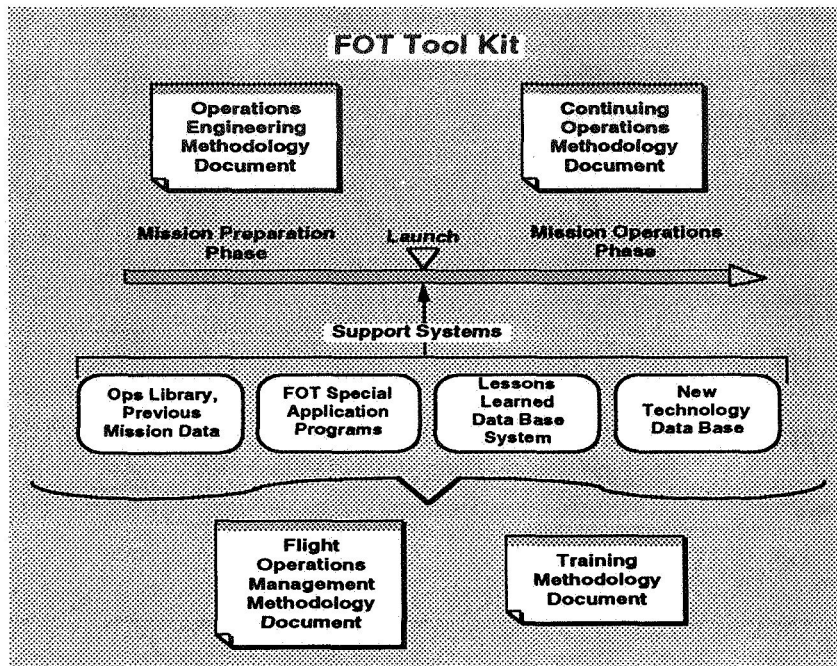


Figure 3: FOT Tool Kit

process improvement. The operations engineering process and FOT Tool Kit efforts are attempts at changing that. The challenge is to first collect the expert knowledge in a defined process, then employ continuous improvement principles in refining the process.

4. FUTURE ENHANCEMENTS

In its present state of development the FOT Tool Kit is a rudimentary collection of information, largely in written form. Enhancements to the Tool Kit would greatly increase its utilization and power. There are plans for development of a FOT life cycle assessment and cost model, a flight operations information collection and management system, a requirements generation

system, and key product development tools.

5. IMPLEMENTATION

The concept of a defined, recognized, and applied operations engineering process and the FOT Tool Kit which supports it has been gaining momentum and recognition throughout the GSFC community. Nearly all GSFC new missions (XTE, TRMM, SOHO, ACE, FUSE) are implementing operations engineering. This is a start, largely from a grassroots effort. There needs to be an investment in full scale development and implementation, as well as organizational changes to fully implement and therefore reap the benefits from it. In the meantime the grassroots effort will continue.

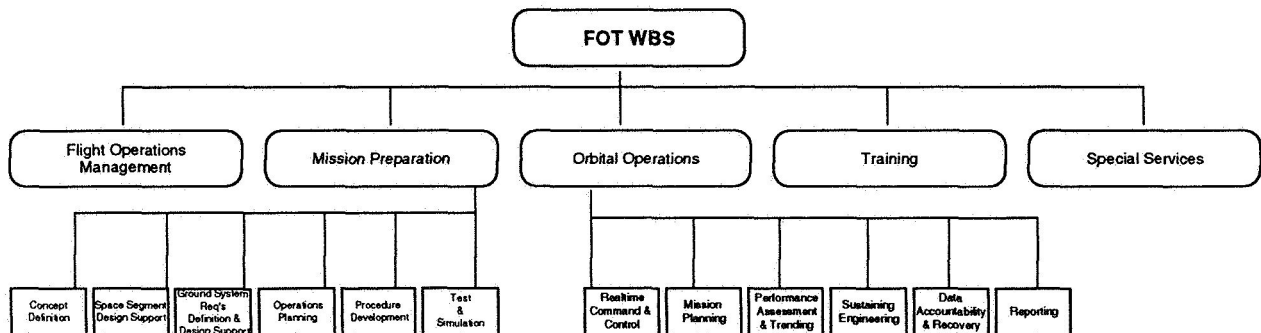


Figure 4: WBS Chart